

## Chapter 22

# Biodiversity in the Islands of Kagoshima

Takahiro OKANO

### 1. Introduction

The plane leaves from Kagoshima Airport heading south, with Mt. Sakura-jima smoldering below. Yakushima Is. comes into view. Also known as a “Floating Alps,” the mountains of Yakushima Is. rise almost 2,000 m out of the ocean surrounded by the Kuroshio Current. Yakushima Is. is a world heritage site famous for its Japanese cedar, some of which are more than 1,000 years old. To the side, long and flat Tanegashima Is., with its rocket base, can be seen. While gazing at the chain of Tokara Islands, the plane begins to descend. Welcomed by coral reefs, white sandy beaches, and the beautiful blue ocean, the plane lands in Amami-Oshima Is. As you get off the plane, you notice the difference in temperature. Depending on the season, there can even be a 10 °C difference. Amami-Oshima Is. is a semitropical island. Even the appearance of its forest differs from that of mainland Kyushu. In the dense subtropical evergreen forests of the Amami Islands, many plants and animals are found which do not exist anywhere else on earth, such as the endemic Amami rabbit.

Kagoshima Prefecture, with its chain of unique islands stretched out 600 km north to south, is a prefecture rich in biodiversity. This biodiversity is supported by the wide diversity of the environment. This article introduces the characteristics of the various environments and their biodiversity, and major species of the islands.

### 2. Environmental diversity

#### 2.1. Three climate zones and abundant rainfall

Geographically, Kagoshima Prefecture stretches over 600 km north to south, with a latitude width of five degrees, from Shishijima Is. rising from Yatsushiro Bay at 32° N to Yoronjima at 27° N. This difference in latitude is reflected in the dif-

ference in temperature. The average temperature in Isa City (average value from 1981 to 2010, the same shall apply hereinafter) is 15.3 °C, 18.6 °C in Kagoshima City, 21.6 °C in Amami City Naze, and 22.4 °C in Okinoerabujima Is. Furthermore, the annual average temperature of Yoronjima Is. to the south was 22.8 °C from 2001 to 2010. The temperature difference of lowland north to south is 7 °C, and is classified as warm-temperate and subtropical climate zones.

The highest mountain of Kagoshima Prefecture, as well as all of Kyushu, is Mt. Miyauranodake (1,936 m). Also in mainland Kyushu, Mt. Karakunidake of Kirishima mountains soars 1,700 m high. As elevation increases, temperature decreases. In winter, air temperature near the mountain top drops below zero and snow can be seen, and the area belongs to the cool-temperature zone.

Due to the world's largest warm current, Kuroshio, rainfall in Kagoshima Prefecture is abundant. Rainfall is especially heavy during the rainy and typhoon seasons. Average rainfall in Isa City (average value from 1981 to 2010, the same shall apply hereinafter) is 2,057 mm, 2,265.7 mm in Kagoshima City, 2,837.7 mm in Amami City Naze, 1,836 mm in Okinoerabujima Is., and 1,740.9 mm in Yoronjima Is. Especially Yakushima Is. is known for its abundant rain. Average rainfall in the seaside areas is 4,477.2 mm, and 8,000-10,000 mm falls in the mountainous areas.

#### 2.2. Two biogeographic areas

Kagoshima Prefecture stretches across two biogeographic areas, reflecting long north to south geographic characteristics, and island formations of the Ryukyu arc from southern Kyushu to Taiwan.

A biogeographic area divides the earth into geographical distribution patterns of plants and

animals. Geographical distribution is determined by terrain which blocks migration, such as an ocean or mountain chain, history of connection and separation of the continent and island, etc. Based on this, the earth is largely divided to six zoogeographic provinces and six floristic kingdoms. Kagoshima Prefecture is classified in the Palearctic and Oriental zoogeographic provinces and in the Boreal and Paleotropical floristic kingdoms. Kagoshima Prefecture is the only prefecture in Japan which is included in two geographical regions.

The border line between the Palearctic region and the Oriental region for land animals such as mammals, terrestrial reptiles, and amphibians, is the Tokara Straits located between Akusekijima Is. and Kodakarajima Is. of the Tokara Islands. This border line is called the "Watase line" (Fig. 1).

During the glacial period, water was stored in the continental glaciers as the earth cooled, and ocean water levels are estimated to be more than 100 m lower. However, the Tokara Straits still existed as water straits because the water depth was more than 1,000 m. As a result, migration of land

animals is assumed to have been blocked, and thus formed a border line. For instance, Habu, a poisonous snake, does not live north of the Tokara Straits.

Looking at the seafloor topography of the Ryukyu arc, there is another 1,000 m + deep trench. This is the Kerama Straits, located south of the Kerama Islands. This is also a borderline for land animals. Regarding Habu snakes, Habu are distributed north of the Kerama Strait, but the Sakishima habu is distributed south of Kerama Strait. Hence, when considering biodiversity of the Ryukyu Islands, the area north of the Tokara Strait is referred to as North Ryukyu, and the area between the Tokara Straits and the Kerama Straits as Middle Ryukyu, and the area south of Kerama Straits as South Ryukyu.

In contrast, the straits between Yakushima Is. and mainland Kyushu, as well as between Tanegashima Is. and mainland Kyushu, are no deeper than 100 m. Consequently, these areas are assumed to have been connected to mainland Kyushu with the 120-140 m drop in sea level during the latest glacial period about 20,000 years ago, allowing land animals such as deer and monkeys macaques migrated freely be-

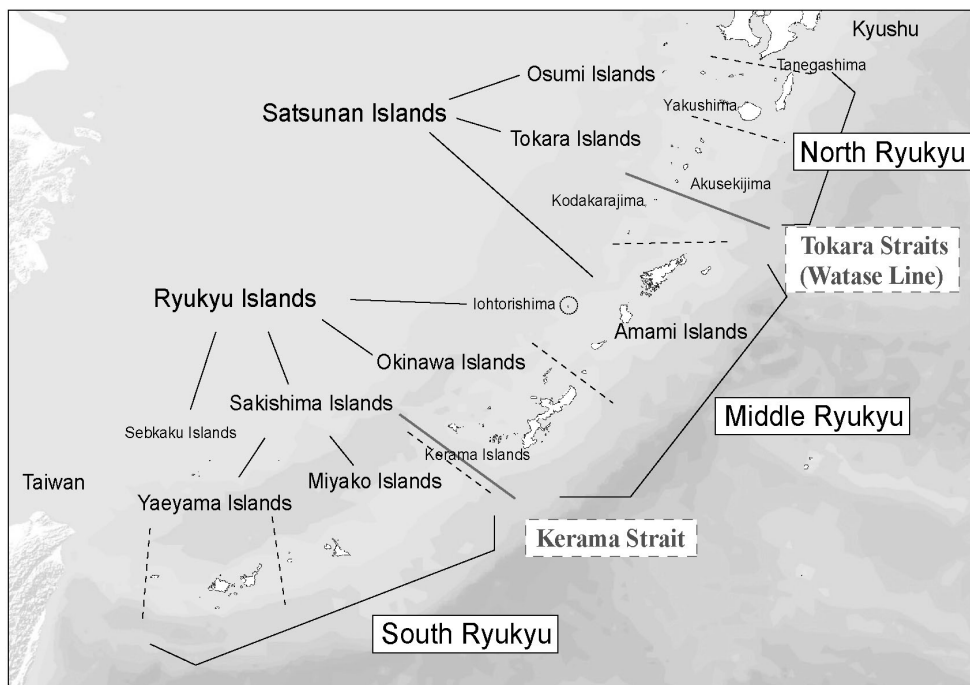


Fig. 1. Map of the island-chain of Kagoshima and Okinawa Prefectures, southern Japan, showing Satsunan and Ryukyu Islands.

tween. As a result, the biota of Yakushima Is. is very close to that of mainland Japan, including Kyushu. Yakushima Is. is the southern limit of the distribution of the Japanese macaque.

Distribution of flora has consistently changed due to the influence of the Kuroshio Current which flows northward. The Satsunan Islands are a transitional zone between the Holarctic floristic kingdom and the Paleotropical floristic kingdom.

### 2.3. 605 Islands

Kagoshima Prefecture has 605 islands, second only to Nagasaki Prefecture. However, according to the total area of the isolated islands is about 2,500 km<sup>2</sup>, Kagoshima is the largest.

Island structure also varies. Some islands were formed as the continent tore apart due to crustal movement. Others were formed volcanic eruption, elevated coral reefs, or elevated seabed sediment on the seabed. Still others were formed by the elevated rocks. The environments of the islands also greatly vary depending on the constitution of the islands.

Furthermore, because of the many islands, the total extension of the coastline is 2,643 km, and is the third longest of all the prefectures in Japan. Coastlines also vary between rock reef, coral reef, pebble beach, sandy beach, and tidelands. Within the sandy beaches, the sandy beaches on Yakushima Is. are comprised of shaved granite and those on Yoronjima Is. by the coral pieces. Large-scale mangrove forests are established at the mouth of Sumiyou River on the Amami-Oshima Is.

### 2.4. Complex topography

Kagoshima Prefecture is one of the prefectures which have many volcanoes in Japan. There are four massive calderas, Kakutou, Aira, Ata, and Kikai, and 11 active volcanoes. The activities of the earth have created a complex topography, and various environments. The activities of active volcanoes have influenced the creatures living nearby, at times have greatly reforming the topography, and disrupting the biota.

Ryukyu Archipelago, which includes the Osumi, Tokara and Amami Islands, is a typical island arc-trench system as the result of the rise and fall of the earth's plates along the ocean trench.

## 3. Characteristics of biodiversity in Kagoshima Prefecture

### 3.1. Various forest types

Plants have optimal conditions and limit values in which to survive, and the areas in which they live are limited by temperature, sunlight, and aridity. Since Kagoshima Prefecture has abundant rainfall, forests have developed to adapt to three climate zones.

An evergreen broadleaf forest developed on Osumi Peninsula, which is a warm-temperate zone. This kind of forest is mainly comprised of evergreen broad leaf trees, such as white oak, Chinquapin (*Castanopsis*), laurels such as Japanese machilus and camphor trees, theaceae such as “*Sakaki*” (*Cleyera japonica*) and camellias. This type of forest is also called a “glossy leaved forest” because the plants have small, thick leaves which can withstand cold and dry conditions, and the surface cuticle layer of the leaves reflects the sunlight. Amami-Oshima and Tokunoshima Is., which belong to the subtropical zone, have subtropical evergreen broadleaf forests comprised of Chinquapin (*Castanopsis sieboldii* known colloquially as “*Sudajiri*”), “*Okinawaurajirogashi*” (*Quercus miyagii*), Japanese machilus, *Distylium racemosum*. For a humid forest to develop at this latitude is unusual in the world.

The high elevations of Kirishima Mountains and Takakuma Mountains are cool-temperature zones of summer-green forests consisting of deciduous broadleaf trees. Takakuma Mountains is the southernmost limit for Japanese beech and Japanese oak, which are the dominant species of the cool-temperate zone.

### 3.2. Rich diversity of species

Because Kagoshima Prefecture has three climate zones and two zoological regions, Kagoshima Prefecture has a rich diversity of species, including 49 mammals, 419 birds, 48 reptiles, and 26 amphibians. Moreover, more than 1,000 land, fresh water, brackish water snail, 200 brackish and fresh water fish, approx. 15,000 insects, approx. 3,100 vascular plants are estimated to be distributed in the area (Table 1). 25-60 % of all animal species in Japan can be found in Kagoshima. When considering that the size of Kagoshima Prefecture is only 2.4 % of all

of Japan, the diversity of species is clearly rich. Supported by complex ocean currents centering on the Kuroshio Current and land stretching north and south, the diversity of marine fish fauna in Kagoshima Prefecture is high. Although the whole image is still not fully understood as an exhaustive survey of fish has just begun, future confirmation of approx. 2,500 species are estimated, and this is thought to be the highest number of fish species in Japan (MOTOMURA 2012).

### 3.3. Many endemic species

When distribution of a plant or animal is limited to a specific area, it is called an "endemic" species. Islands surrounded by ocean water have a higher rate plant and animal endemism, because migration and interaction with other areas are blocked. In Kagoshima Prefecture, the endemic species have diversely evolved due to the existence of various islands of different constitutions.

There are some different processes which create endemic species. One case is where each island has a unique environment and species develop their individual evolutionary history. As species, which

once belonged to one species, become isolated on various islands which have been separated due to a rise in sea level, etc., the species differentiate into endemic species and subspecies on each island. Otton frogs which live in Amami-Oshima and Kakeromajima Is. and Holst's frogs which are distributed throughout the Okinawa Islands can be considered as examples.

Another case is where a species used to be widely distributed, but due to some reason, such as competition with another species or change in the environment, generally became extinct, yet survived on a certain island. This condition is called a "relict" species. The Amami rabbit, distributed only on Amami-Oshima and Tokunoshima Is., is a prime example. The Amami rabbit is estimated to have diverged from the Leporidae group in the mid-Miocene period (about 10 million years ago), and is called a "living fossil" because it has no existing related species, and has remained in its primitive form. When compared with other Leporidae species, the forelegs, hind legs and ears are shorter, and it cannot jump high like most rabbits. This species used to be widely distributed throughout the continent, but

Table 1. Number of native species in Kagoshima Prefecture

	Number of native species in Japan (A)	Number of native species in Kagoshima Prefecture (B)	B/A (%)	Number of threatened species (CR, EN, VU) in Kagoshima Prefecture (C)
Manmalls	About 180	49	25.0	12
Birds	680	419	61.6	42
Reptiles	96	48	45.8	11
Amphibians	65	26	40.0	7
Brackish- and Fresh-water fishes	About 400	200 +	50.0	43
Insects	About 30,000	About 15,000	46.9	35
Land, Fresh- and Brackish-water snails	About 1,100	1,000 +	90.9	103
Brackish- and Fresh-water decapods	197	70	35.5	3
Fishes	About 4,000	About 2,500	62.5	
Vascular plants	About 7,000	About 3,100	44.3	512

source: Kagoshima Prefecture (2012).

(A) is number of native species for evaluation in the Red List of the Ministry of the Environment (2006, 2007), (B) is number of native species for evaluation in the Red Data Book of Kagoshima Prefecture (2003), exclude Reptiles, Amphibians, Fishes and Vascular plants. Regarding Reptiles and Amphibians, the source is the list of Japanese names of Reptiles and Amphibians in Japan made by the Herpetological Society of Japan (27/08/2012 draft). Regarding Fishes, the source is Motomura (2012).

(C) is base on the Red List of the Ministry of the Environment. Regarding Reptiles and Amphibians, base on edition in 2012. Regarding Vascular plants from, base on edition in 2000. The other is base on edition in 2006 and 2007.

went extinct for some reason, such as competition with other Leporidae or other animals, or a change in the environment. However, they are thought to have been able to survive on Amami-Oshima and Tokunoshima Is. because these islands were separated from the continent since ancient times and no competing animals were introduced to the islands.

#### 3.4. Northern and southern limits

Kagoshima Prefecture is elongated north to south, and includes the boundary between biogeographic areas. As a result, Kagoshima Prefecture is the northern or southern limit of distribution for many plants and animals have.

The distribution boundary of organism to the north is called the northern limit. For southern organism with a center of distribution in warmer areas, the northern distribution limit is determined by restrictive characteristics such as the temperature in the northern hemisphere. The opposite is the southern limit, where the distribution of northern organism with a center of distribution in colder areas is determined by the restrictive characteristics of a higher temperature, stronger sunlight, and aridity. In addition, the northern and southern limits may also be determined by obstacles in establishment due to competition with other organism or blockage of migration due to a water strait, etc (MIYAMOTO 2010).

Regarding plants, as Kagoshima Prefecture stretches between the subtropical and warm-temperate zones, there are many cases where Kagoshima is the northern limit for southern plants which are mainly distributed in the tropical zone, and the southern limit for northern plants which are mainly distributed in cool-temperature and warm-temperature zones. Yakushima Is. is the southern limit for more than 200 plants, and the northern limit for more than a few plants (Ministry of the Environment *et al.* 2012). While Amami Islands is the southern limit for 97 plants, it is also the northern limit for 239 plants (Kagoshima University 2012).

Water straits are a boundary which hinders land animal migration. mainland Kyushu is the southern limit for mammals such as raccoon dogs, Japanese weasels, and Japanese martens. Yakushima Is. macaques, a subspecies of Japanese macaques, are distributed on Yakushima, which is the southern limit

of Japanese macaques. Yakushima Is. is the southern limit of reptiles such as Japanese ratsnakes and Tiger keelbacks, and Amami-Oshima Is. is the northern limit of Habu snakes and Hime habu. Regarding amphibians, southern Kyushu is the southern limit for Tago's Brown frogs and Kajika frogs, and Yakushima is the southern limit for Japanese Tree frogs. Kuchinoshima Is. is the northern limit for Ryukyu Kajika frogs, and Amami-Oshima Is. is the northern limit of Hallowell's Tree frogs (Kagoshima Environmental Studies Workshop 2009).

Kagoshima Prefecture is influenced by the warm Kuroshio Current, and is the northern limit of the global distribution of coral reefs. The area of Japan with coral communities is divided into two regions based on the sea surface temperature in the coldest month, 18 °C, which is considered to be needed for coral reef formation. It is region where coral reefs form and region where reefs rarely formed, although coral communities are distributed. This boundary is between the Osumi peninsula and Tanegashima Is.

151 hermatypic coral species have been confirmed in the sea around Tanegashima Is. The composition of coral species in Tanegashima Is. is significantly different from that in Amami-Oshima Ia. Southward along the Tokara Strait, the number of species greatly increases. In the sea around the Amami Islands, about 220 species of hermatypic corals have been confirmed.

Development of coral reef is rarely seen in Nagashima and Shishijima Is. in northern part of Kagoshima Prefecture, but many hermatypic coral have been confirmed. Coral communities have also been confirmed in the sea around Koshikijima Is., Sakurajima, and Satamisaki, with 17 species in the sea around Sakurajima and 23 species in the sea around Satamisaki (Ministry of the Environment and Japanese Coral Reef Society 2004).

#### 3.5. Endangered species

There are many endangered species in Kagoshima. Reasons for this include human-caused effects such as forest development and logging, ocean and river development, negative changes in the environment due to the reduction of human conservation activities, as well as factors such as many endemic

species with small populations living in a limited distribution. Furthermore, there may be cases where species have gone extinct in other places, but somehow remain in Kagoshima.

Many species listed in the Red List of the Ministry of the Environment, are distributed in Kagoshima Prefecture (Table 1). In particular, species which are distributed in island areas such as the Amami Islands and Yakushima Is., are listed as the endangered species.

Kagoshima Prefecture published a prefectural Red Data Book edition in 2003. Kagoshima Prefecture has many islands, and the status of a species varies on each island, even within same species. Consequently, from the standpoint of preserving genetic diversity, original classification terms such as “Vanished,” “Vanish endangered Category I/II,” “Semi-vanished endangere” in “local population.” 4,467 plant and animal species have been specifically included (Table 2).

#### 4. Biodiversity of islands in Kagoshima

##### 4.1. Koshikijima Is.

Koshikijima Is. is located in the East China Sea, about 40 km west of Satsuma peninsula, and is part of a group of isolated islands including habited islands Kami-Koshikijima, Naka-Koshikijima, and Shimo-Koshikijima Is., and other surrounding small islands. Since the islands were connected to mainland Kyushu during the glacial stage, the biota is close to that of mainland Kyushu.

On the northeast coast of Kami-Koshikijima Is., there is a 4 km of barrier beach called “Nagame no Hama” and offers a beautiful lanscape. Kuwasakiike,

Kaiike, and Namakoike, which are closed off by this barrier beach, are brackish lakes whose water level and quality are affected by the ocean. Chromatiales (purple sulfur bacteria), a type of fossil microbe, live in Kaiike.

“Ubamegashi” oakforests (*Quercus phillyraeoides*), which are wind beaten scrub forests, grow along the cliffs in the steep seacoast zone, and clusters mainly of *Rhaphiolepis umbellate*, Japanese *Pittosporum* (*Pittosporum tobira*) and *Eurya emerginata* can also be seen. Large spiny tree ferns grow naturally in the valley, and this habitat is the northern limit of the tree ferns and has been designated as a Natural Monument. Moreover, Japanese lily (*Lilium speciosum*) grows among the Japanese pampas grass “*Susuki*” (*Miscanthus*) in the meadows and plains.

Mammals such as the Japanese weasel (*Mustela itatsi*) and Kyushu hare (*Lepus brachyurus brachyurus*) are present as well as birds, such as the eastern reef heron (*Egretta sacra*), Japanese pheasant (*Phasianus versicolor*), tit, grey wagtail (*Motacilla cinerea*), Japanese wood pigeon (*Columba janthina*; Natural Monument). In addition many birds such as the yellow wagtail (*Motacilla flava*), yellow breasted bunting (*Emberiza aureola*), and black-capped kingfisher (*Halcyon pileata*) pass through during their spring and fall migrations, making this area an important stopover for migratory birds. Furthermore, black-tailed gulls (*Larus crassirostris*) nest on the Kashima cliffs in Shimo-Koshikijima Is., and this is the southern limit of their breeding area.

Table 2. Number of threatened Species included in the Red Data Book of Kagoshima Prefecture (2003)

	Extinct	Extinct in the Wild	Threatened: Endangered	Threatened: Vulnerable	Near Threatened	Important on distributive characteristics	Data Deficient	Subtotal
Manmals	3	0	10	8	3	18	4	46
Birds	0	0	17	24	15	8	14	78
Reptiles	0	0	2	3	9	21	3	38
Amphibians	0	0	2	6	4	13	0	25
fishes	0	0	19	5	8	79	21	132
Insects	0	0	28	35	52	1,110	24	1,249
Land, Fresh- and Brackish-water snails	8	0	65	74	193	38	89	467
Brackish- and Fresh-water decapods	0	0	7	4	19	38	3	71
Vascular plants	5	3	490	423	756	590	94	2,361
Total	16	3	640	582	1,059	1,915	252	4,467



#### 4.2. Yakushima Is.

Yakushima Is. is an almost completely round island with a circumference of 130 km, and is located 60 km off the southern tip of mainland Kyushu. There are 11 mountains higher than 1,500 m, including Mt. Miyanouradake (1,936 m), the highest mountain in Kyushu.

The biota is close to mainland Kyushu, since it used to be connected to mainland Kyushu until about 20,000 years ago, but Yakushima's primitive natural environment was prone to change and produced a unique ecological system in Yakushima Is., where endemic species and subspecies can be seen. Yakushima Is. was inscribed on the World Heritage List as a natural property in 1993.

Subtropical to cool-temperate forests can be seen in Yakushima Is. Subtropical flora such as *Ficus superba* and Chinese banyan (*Ficus microcarpa*) grow along the coast, which belongs to the subtropical zone. Warm-temperature zone broad-leaved evergreen forests have developed from the coastline to nearly 700-800 m along the warm-temperature zone mountainsides, and warm-temperature zone conifer forests comprised of Japanese cedar "Sugi" (*Cryptomeria japonica*) grow at elevations from around 700-800 m to 1,200 m. At elevations approaching 1,200-1,800 m in the cool-temperature zone, there are cool-temperate conifer forests and above that, scrub forests of Yakushima dwarf bamboo (*Pseudosasa owatarii*) and Yakushima rhododendron (*Rhododendron yakushimanum*) at the mountain summit. At the southern edge of Japan near elevations of 1,600 m in cool-temperature zone, there are high moors comprised of peat moss, "Yakushima-koke-sumire" (*Viola verecunda* var. *yakusimana*), etc. On the other hand, all the climates of the Japanese islands, from Hokkaido to Kyushu are condensed on this one island, however, representative tree species of the cool-temperature zone on the mainland such as Japanese beech, "Mizunara" (*Quercus crispula blume*), etc., are noticeably missing. The distribution of plants according elevations such as this is called "vertical distribution of vegetation."

Natural Japanese cedar is distributed from elevations between about 600-1,800 m in the center of the island. Those trees usually live up to 800 years

in other areas in Japan. However, trees living more than 1,000 years are not uncommon in Yakushima Is. Because, Yakushima Is. has abundant rain and high humidity, natural Japanese cedar grows very slowly, and does not rot easily due to its high resin content and tight rings. In Yakushima Is, natural Japanese cedar trees older than 1,000 years old are called as "Yakusugi," and trees less than 1,000 years old are called as "Kosugi." Virgin and natural forests with *Yakusugi* trees over 3,000 years old provide a unique and beautiful scenery. The vertical distribution of vegetation, and the beautiful scenery of virgin forests which includes *Yakusugi*, are reasons why Yakushima Is. has been inscribed on the World Heritage List.

Added to the more than 1,900 species of flora, there are 600 species of moss. Yakushima Is. is the southern limit for more than 200 species of plants, such as Japanese fir (*Abies firma*), Southern Japanese hemlock (*Tsuga sieboldii*), and Japanese cedar, and is the northern limit for many species, such as *Caesalpinia crista*, "Oni hinoki shida" (*Asplenium x kenzoi*). Many endemic and endangered species have been confirmed, such as species which are restricted to the highlands, and species which grow in specific environments such as rocky areas and mountain streams (Ministry of the Environment *et al.* 2012). 16 species of mammals, including four endemic subspecies, Yakusika deer (*Cervus nippon yakushimae*), Yakushima macaque (*Macaca fuscata yakui*), Yakushima Dsinezumi shrew (*Crocidura dsinezumi umbrina*), and Yakushima small Japanese field mouse (*Apodemus argenteus yakui*), have been confirmed. 167 species of birds, including two endemic subspecies, *Garrulus glandarius orill* and *Parus varius yakushimensis*, have confirmed, and four species, Ryukyu robin (*Erithacus komadori*), Japanese wood pigeon, Izu Leaf-warbler (*Phylloscopus ijimae*), and Izu Thrush (*Turdus celaenops*) have been designated as Natural Monument. In addition to these, 15 species of reptiles, 8 species of amphibians, and approximately 1,900 insects species have been confirmed, Yakushima Is. has an extremely abundant biota for an island with such small dimensions.

On the northwestern side of the island in Nagata, Maehama, Inaka-hama, Yotsuse-hama are beautiful

white beaches comprised of shaved granite sand. Every year, Loggerhead Sea Turtles come to nest on these beaches. As these beaches have the highest number of nesting in the north Pacific region, it is a crucial habitat in the lifecycle of the turtle. The three beaches, collectively called “Nagatahama,” have been designated as protected wetlands under the Ramsar Convention.

Loggerhead sea turtles mainly visit Nagatahama to lay eggs from May to July. It takes a female about 30 minutes to dig a hole and lay 60-100 eggs. Every year, 2,000-3,000 turtles arrive on the beach to lay eggs.

A comprehensive survey of the fish of Yakushima Is. was carried out in 2008-2009, by ten agencies in Japan, including Kagoshima University Museum and National Museum of Nature and Science. As a result, 24 orders, 112 families, 382 genus, and 951 species of marine (including brackish water) fish were recorded, and various fish could be confirmed (MOTOMURA and MATSUURA 2010).

#### 4.3. Tokara Islands

Tokara Islands are a transitional zone between the warm-temperature and the subtropical zones, and are located on the boundary of two biogeographic areas. As a result, the islands are the northern or southern limit for many plants and animals. Moreover, many endemic species which have evolved as the islands became isolated can be seen.

Most of the islands belong to a volcanic zone. There are volcanos such as Mt. Otake of Nakanoshima Is., called *Tokara-Fuji*, and Mt. Otake of Suwanosejima Is. which is active even today. The islands from Kuchinoshima to Akusekijima Is. have the characteristic landscape of a volcanic island, surrounded by extremely high and low cliffs, as well as gushing hot springs, considered to be one of the blessings from volcanoes, as places of recreation and relaxation for people on the island. Kodakarajima and Takarajima are islands of raised limestone, with many flatlands and coral reefs surrounding them.

The “*Tokara-Habu*” (*Protobothrops tokarensis*) is endemic to Takarajima and Kodakarajima Is., and Kodakarajima Is. is northern limit of distribution for *Habu* (*Protobothrops*) snakes, as well as for Green

Grass lizards “*Aokanahebi*” (*Takydromus smaragdinus*) and Ryukyu green snakes (*Cycphiops semicarinatus*). In contrast, Suwanosejima Is. is the southern limit for the Japanese Grass Lizard (*Takydromus tachydromoides*) which is distributed from Hokkaido to Kyushu. However, there are cases of species expanding their distribution to north from the Tokara strait, while others are expanding south from Tokara strait, such as Hokou gecko (*Gekko hokouensis*). Takara gecko (*Gekko shibatai*) is endemic species in Takarajima and Kodakarajima Is.

Regarding amphibians, Ryukyu Kajika frogs (*Buergeria japonica*), are widely distributed south from the Tokara Straits, and Kuchinoshima Is. is its northern limit.

In consideration of mammals, wild cattle in Kuchinoshima Is. are considered to be an ancient Japanese native species, Tokara goats (*Capra hircus domestic*) were widely distributed from the Ryukyu Archipelago to Indonesia. Erabu flying fox (*Pteropus dasymallusdasymallus*) which lives on Nakanoshima and Takarajima Is., has been designated as Natural Monument. Nakanoshima Is. is also the grazing land for Tokara ponies (*Equus caballus*).

116 species (and subspecies) of birds have been confirmed, including the Izu Thrush, Izu Leaf-warbler, and Ryukyu robin. Moreover, Tokara Islands are a point of passage for migratory birds, and many kinds of birds can be seen in during the spring and fall migration seasons.

Various species of insects, such as *Dicerca nishidai* beetle, flat-headed wood-borer, and *Hemicordulia mindana nipponica* dragonfly, have been confirmed.

Regarding plants, groves of *Pandanus odoratissimus* are found in Kuchinoshima Is. the pine’s northern limit, and clusters of *Rhododendron tamurae Masam* can be seen in the volcano wilderness of Nakanoshima and Suwanosejima Is. Suwanosejima Is. is the southern limit for Japanese Green Alders (*Alnus viridis*) and Takajima Is. is the northern limit for clusters of *Heliotropium foertherianum*.

#### 4.4. Amami Islands

Amami Islands are characterized by subtropical evergreen broadleaf forest and many endemic species.



The forests on Amami-Oshima and Tokunoshima Is. are green all year round. Following the same latitude across the globe, there are many arid regions, such as Mexico on the American continent and the Sahara desert on the African continent. This fact shows how rare the humid forests across the Amami Islands are. The moist climate with abundant rain has produced a subtropical evergreen broadleaf forest consisting of trees of the *Castanopsis* group and white oak. Ferns are also abundant, including the Flying Spider-monkey Tree Fern (*Cyathea lepifera*) which reaches heights exceeding 10 m. Plants also grow on the fronds and trunk of the tree. Plants whose roots grow in the tops of trees or on rocks, instead of in the ground are called “epiphytes,” and a humid forest is also a reservoir of epiphytes. 1,334 species of vascular plant have confirmed in Amami-Oshima Is., 68 species are endemic (Kagoshima University 2012).

Islands of the Ryukyu Archipelago, including Amami-Oshima Is., were originally continental islands connected to the Eurasian continent. The present configuration of the islands is considered to have been formed mostly through the initial formation and expansion of the Okinawa Trough and through other radical tectonic movements since about 15 million years ago, changes in the sea level caused by climate change since about 1.7 million years ago, and sedimentation of the Ryukyu Limestone associated with the development of coral reefs. (KIMURA 1996, KIZAKI and OSHIRO 1980, KIZAKI 1997, OTA *et al.* 2001).

The biota of the island reflects the history of the island. When the area was separated from the continent, it became an island with the terrestrial plants and animals of that time. As time passed, the plants and animals began to follow an original evolutionary path. The island further divided into smaller islands, and the plants and animals diverged into different species on each island. Furthermore, the repeated rise and fall of the sea level due to climate change, which became especially significant since about 1.7 million years ago, resulted in the repeated separation and connection between neighboring islands, and in turn, the continuous isolation and interaction of plants and animals.

Characteristics of the biota in the Amami

Islands are the many endemic species, especially relict species. This is because the Middle Ryukyu islands including the Amami Islands have a longer history of isolation from the continent, since at least the early Pleistocene of the Quaternary Era (about 2 million years ago until about 1.7 million years ago).

Such relict species are generally characterized by prominent geographical and genetic gaps from extant sister populations outside the Middle Ryukyu. Prominent faunal representatives of such relict endemisms are the Amami rabbit (*Pentalagus furnessi*), Ryukyu long-furred rat (*Diplothrix legata*), three spiny rat species of the genus (two species are distributed on the Amami Islands), Lidth's jay (*Garrulus lidthi*), Kuroiwa's grounded gecko (*Goniurosaurus kuroiwaie splendens*, a subspecies distributed on Tokunoshima Is.), and Anderson's crocodile newt (*Echinotriton andersoni*). Floral representatives are *Arisaema heterocephalum*, *Viola amamiana*, and *Polystichum oboae*. The Amami Islands are an “Ark” of terrestrial plants and animals from an ancient continent.

14 species of land mammals, including four endemic species, namely the Amami rabbit, Amami spiny rat, Tokunoshima spiny rat, and Orii's shrew, have been confirmed. The Watase's Shrew (*Crocidura watasei*) and Ryukyu long-furred rat, which are also distributed throughout the Okinawan islands, are endemic to Middle Ryukyu. 18 species of land reptiles, including two endemic species, namely Banded ground gecko (*Goniurosaurus kuroiwaie splendens*) and Hyan coral snake (*Sinomicrurus japonicus japonicus*), have been confirmed. The Okinawan tree lizard (*Japalura polygonata polygonata*), Barbour's blue-tailed skink (*Plestiodon barbouri*), Amami odd-scaled snake (*Achalinus wernerii*), Hai coral snake (*Sinomicrurus japonicus boettgeri*), Habu (*Protobothrops flavoviridis*), and Himehabu (*Ovophis okinavensis*) are endemic to Middle Ryukyu. 12 species of amphibians have been confirmed, including four endemic species, namely Amami Red Tree Frog, Amami Tip-nosed Frog (*Odorrana amamiensis*), Amami Ishikawa Frog (*Odorrana splendida*), and the Otton Frog (*Rana subaspera*), and a subspecies of the Amami Green Tree Frog (*Rhacophorus viridis amamiensis*). The Sword-Tailed Newt (*Cynops ensicau-*

da) and Anderson's Crocodile Newt are endemic to Middle Ryukyu. 226 species of land, fresh water, and brackish water snails have also been confirmed (Kagoshima University 2012).

269 species (and subspecies) of birds have been confirmed, Lidth's jay is endemic to the Amami Islands and the Amami woodcock to the Middle Ryukyu. Lidth's jay, Amami thrush (*Zoothera dauma major* = *Z. d. amami*), Owston's woodpecker (*Dendrocopos leucotos owstoni*), and Ryukyu Robin have been designated as Natural Monument. Birdlife International selected the islands of the Ryukyu Archipelago including the Amami islands, under the title "Nansei Shoto," as one of the "Endemic Bird Areas of the World," based on the inhabitation of endemic species such as the Lidth's jay and Amami woodcock. There are also many migratory birds, the Amami Islands is a mecca for bird watchers.

The sweetfish, "Ryukyu-Ayu" (*Plecoglossus altivelis ryukyuensis*) live mainly in Sumiyou Bay and the rivers emptying into Yakiuchi Bay in Amami-Oshima Is. *Ryukyu-Ayu* has been identified as a subspecies distinct from *Ayu* on mainland Japan morphologically, ecologically, and genetically. This subspecies is thought to have an original history at the 1 million year level, with Tokara Strait as its boundary (Kagoshima Prefecture 2003).

## 5. Conclusion

The tentative list of the "Amami-Ryukyu" covering islands ranging from the Amami Islands to the Sakishima Islands was submitted in January 2013. Submission of this tentative list is part of the procedure to officially express the intention as a country to recommend the area as a world heritage site. If this area is inscribed on the World Heritage List, Kagoshima Prefecture will be the only prefecture in Japan which would have two World Heritage sites as a natural property, with Yakushima Is. already registered as one.

Kagoshima Prefecture has many islands, with various plants and animals living on them. Please come and meet the many plants and animals, and

experience the rich biodiversity of Kagoshima. It will surely teach us the mysteries of life.

## References

- Kagoshima Environmental Studies Workshop (ed.) 2009. 100 Environmental Keywords in Kagoshima Prefecture. 245 pp., Nanpoushinsha, Kagoshima. (in Japanese)
- Kagoshima Prefecture 2003. Kagoshima Red Data Book. 642 pp., Kagoshima Environmental Research and Service, Kagoshima. (in Japanese)
- Kagoshima Prefecture 2012. Nature of Kagoshima. 26 pp., Kagoshima Prefecture, Kagoshima. (in Japanese)
- Kagoshima University 2012. "Consideration Report to Establish a Management System based on the Scientific Knowledge for Registration of the Ryukyu Archipelago as a World Natural Heritage Site 2011." 80 pp., Kagoshima University, Kagoshima. (in Japanese)
- KIMURA, M. 1996. Quaternary Era Paleogeography of the Ryukyu Archipelago. *Journal of Geography* 105: 259-285. (in Japanese)
- KIZAKI, K. and OOSHIRO, I. 1980. Background of Ryukyu Islands. In: *Natural History of Ryukyu* (Ed. Kizaki, K.), pp. 8-37, Tsukiji Shokan Publishing Co., Ltd., Tokyo. (in Japanese)
- KIZAKI, K. 1997. The Way Plants and Animals Came, In: *Knowing Nature of Okinawa* (Eds. IKEHARA, S. and KATO, Y.), pp. 14-32, Tsukiji Shokan Publishing Co., Ltd., Tokyo. (in Japanese)
- MİYAMOTO, J. 2010. Plants of Amami Islands. In: *Kagoshima Environmental Studies II* (Ed. Kagoshima Environmental Studies Workshop, Kagoshima University), pp. 65-83, Nanpoushinsha, Kagoshima. (in Japanese)
- MOTOMURA, H. 2012. Diversity of Fish Species in Kagoshima Prefecture generated by the Kuroshio Current. In: *Fishes in Kuroshio Current* (Ed. MATSUURA, K.), pp. 19-43, Tokai University Press, Kanagawa. (in Japanese)
- MOTOMURA, H. and MATSUURA, K. (eds.) 2010. *Fishes of Yaku-shima Island, Kagoshima, southern Japan*. 264 pp., National Museum of Nature and Science, Tokyo.
- Ministry of the Environment 2006. *Red List of the Ministry of the Environment*. Ministry of the Environment, Tokyo.
- Ministry of the Environment 2007. *Ditto*.
- Ministry of the Environment and Japanese Coral Reef Society (eds.) 2004. *Coral Reefs of Japan*. 356 pp., Ministry of the Environment, Tokyo,
- Ministry of the Environment, Forest Agency, Agency for Cultural Affairs, Kagoshima Prefecture and Yakushima Town 2012. *Yakushima World Heritage Site Management Plan*. 24 pp., Ministry of the Environment; Forest Agency; Agency for Cultural Affairs, Kagoshima Prefecture, Yakushima Town, Tokyo. (in Japanese)
- OGTA, Y. *et al.* 2001. Landform Development History of Nansei Islands. In: *Landform of Japan 7 Kyushu / Nansei Islands* (Eds. MACHIDA, H. *et al.*), pp. 301-314. University of Tokyo Press, Tokyo. (in Japanese)